Ferroelectricity Newsletter

A quarterly update on what's happening in the field of ferroelectricity

Volume 5, Number 2 Spring 1997

CONFERENCE PRESENTATIONS REFLECT SUBSTANTIAL PROGRESS IN THE FIELD OF FERROELECTRICS

One of the advantages of the exploding information revolution is the fast dissemination of data. Thanks to the expedient work of **Duane Dimos** of Sandia National Laboratories, who served as one of the General Technical Program Co-chairmen at the **9th International Symposium on Integrated Ferroelectrics**, we can bring you not only the complete list of talks and poster presentations given at that meeting, but also a quite detailed report on the exciting developments discussed at this conference, held 2-5 March in Santa Fe.

In this issue we continue the listing of paper and poster presentations at the **10th International Symposium on the Applications of Ferroelectrics**, which took place 18-21 August 1996 at Rutgers University in New Jersey. As you will see, the mere number of talks and posters is so high that these conference papers took up more than half of the space available in this issue.

The **Calendar of Events** gives you a taste of what to expect in 1998 as far as conferences are concerned. On page 24 you will find out about the dates and venues of the following meetings:

- 10th International Symposium on Integrated Ferroelectrics in Monterey, California
- 5th International Symposium on Ferroic Domains and Mesoscopic Structures at the Pennsylvania State University in Pennsylvania
- International Symposium on Applications of Ferroelectrics in Montreux
- European Conference on Applications of Polar Dielectrics in Montreux
- Electroceramics VI in Montreux
- 2nd Asian Meeting on Ferroelectrics in Singapore

You will find details of these conferences in the next issue of the *Ferroelectricity Newsletter* to come out at the end of July. This listing of important events in the field of ferroelectricity is not yet complete. We encourage organizers to send us information about upcoming meetings so that we can offer our readers as comprehensive a list as possible.

-- Rudolf Panholzer
Editor-in-Chief

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ISIF 97 PAPERS

The following is a list of titles and authors of presentations given at the ***Ninth International Symposium on Integrated Ferroelectrics****, held 2-5 March 1997 in Santa Fe, New Mexico.*

Plenary Session

Reliability of ferroelectric memories using layered perovskites
C.A. Paz de Araujo

Current status and prospects of MFSFTs and related devices
H. Ishiwara

Ferroelectric films for nonvolatile memories and DRAMs
A.I. Kingon

Emerging technologies for ferroelectric films and coatings
M. Sayer

Chemical Solution Deposition

Fabrication of ferroelectric $Bi_4Ti_3O_{12}$ thin films and micropatterns by means of chemical solution decomposition and electron beam irradiation
S. Okamura, K. Mori, and T. Tsukamoto

Characterization of self-patterned SBNT thin films from photosensitive solutions
H. Uchida, N. Soyama, K. Kageyama, K. Ogi, M.C. Scott, J.D. Cuchiaro, L. McMillan, and C.A. Paz de Araujo

Effect of TiO_x nucleation layer on crystallization of sol-gel derived $Bi_4Ti_3O_{12}$ films
D.A. Neumayer, P. Duncombe, R. Laibowitz, and A. Grill

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NINTH INTERNATIONAL SYMPOSIUM ON INTEGRATED FERROELECTRICS (ISIF 97)

The 9th annual ISIF meeting was held 2-5 March in Santa Fe, New Mexico. The technical program chairs for the meeting were Duane Dimos and Bruce A. Tuttle, both from Sandia National Laboratories in Albuquerque, New Mexico. This year's ISIF was the largest to date with nearly 300 attendees and more than 160 submitted abstracts. Roughly two thirds of the papers were given as talks with the others presented as posters.

The meeting started with a plenary lecture session. Carlos Araujo (Symetrix, Inc.) began by describing the excellent progress being made in developing FRAMs, based primarily on the layered perovskites typified by $SrBi_2Ta_2O_9$(SBT), for applications such as embedded memories, RF ID tags and smart cards. He also stated that the next principal challenge was to obtain stable enough properties to permit 1T-1C architectures. Hiroshi Ishiwara (Tokyo Institute of Technology) then showed that good progress has been made on developing field effect devices using $Pb(Zr,Ti)O_3$(PZT), SBT, and $BaMgF_4$. The devices typically require buffer layers between the Si and ferroelectric films and need to demonstrate improved retention. Angus Kingon (North Carolina State University) then discussed the excellent progress that has been made in understanding numerous materials issues associated with developing FRAMs using PZT and DRAMs using $(Ba,Sr)TiO_3$. Finally Michael Sayer (Queen's University) presented work on micromechanical devices that used thicker films (1-10μm). One of the novel processing aspects was the use of fine PZT powders in a sol-gel matrix to more readily achieve thick PZT layers.

The session on nonvolatile memories included invited talks by Bob Jones (Motorola), T. Otsuki (Matsushita), and D. Kim (Samsung). This session emphasized that steady progress is being made in the development of FRAMs, which is still the key application for integrated ferroelectrics. The majority of the work worldwide is focused on the Bi-layered perovskites, but significant work is still being done on PZT FRAMs. Reducing the film thickness to achieve 1.5V operation in memories appears reasonable, but will require greater process control than has typically been demonstrated. At this point, the most serious issues seem to be associated with degradation of the ferroelectric during the final stages of processing, particularly forming gas anneals. The first application of FRAMs will probably be for RF ID tags and smart cards (Derbenwick, Celis Corporation), since these applications are less demanding with respect to memory size. The poster session also showed that significant progress has been made in developing nondestructive readout devices (Radiant Technologies, Fujitsu) and device simulators (KIST, Symetrix Corporation).

New dielectrics for high-density DRAMs is the other most widely pursued application for this class of thin films. Invited talks in the DRAM session by

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Paul Schuele (Micron Technology) and D.-H. Lee (Hyundai) described the necessity of being able to integrate advanced dielectrics such as BST and some of the technical difficulties associated with BST integration. Even BST dielectrics will be incorporated as 3-D capacitors, rather than planar structures, which will require the conformality of a chemical vapor deposition (CVD) process. Excellent progress has been made in this field as emphasized in the invited talk by K. Ono (Mitsubishi). Improvements in the deposition of BST films have also resulted in improved effective permittivities for very thin films. Schuele indicated, however, that Ta_2O_5 would be the first new dielectric to be incorporated in advanced DRAMs (4Gb & 16 Gb), particularly since the issue of obtaining a conducive plug that is compatible with the BST process has not been completely resolved.

The interest in ferroelectric (and related) thin films is still being fueled primarily by nonvolatile memory (FRAM) and DRAM applications. Significant progress, however, is also being made in piezoelectric, pyroelectric, and dielectric applications, as highlighted in sessions of each of these topics. The session on dielectric properties covered high permittivity films for use as standard capacitors and voltage tunable capacitors. PZT and BST thin films are being evaluated for integrated passive components (Klee, Philips GmbH) and decoupling capacitors (Bland, GEC Marconi). The invited talk by D. Ueda (Matsushita) discussed the excellent reliability characteristics of integrated BST decoupling capacitors on GaAs MMICs, which are now in large-scale production. In addition to traditional capacitor applications, the strong dependence of permittivity on voltage for ferroelectrics is being exploited to develop tunable devices. The invited talk by Felix Miranda (NASA Lewis) discussed how $SrTiO_3$ (STO) films are being integrated with high-temperature superconducting oxide films for tunable filters and phase shifters. Raymond (Sandia National Labs) and Mueller (SCT, Inc.) demonstrated the substantial progress that has been made in improving the tunability and reducing the loss of STO and BST films in characterizing intermodulation distortion.

Ferroelectric thin films also offer tremendous potential for replacing bulk ferroelectrics (i.e., BST) in infrared (IR) imaging systems. This replacement would significantly reduce the cost of these systems, while also improving resolution and sensitivity, as discussed in the invited talk by Kevin Sweetser (Texas Instruments). In the other invited talk, Neil Shorrocks (GEC Marconi) showed that PZT thin films can be successfully integrated with fully metallized ICs at a processing temperature around 450˚-480˚C, which greatly simplifies the construction of fully integrated devices. Paul Clem (Sandia National Labs) described the excellent temperature sensitivity obtained by incorporating an aerogel layer with a PZT film. Use of an aerogel film alleviates the need to form free-standing pixel structures, while providing excellent thermal insulation.

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Low-temperature crystallization and ferroelectric properties of sol-gel derived layer-structured perovskite thin films
K. Kato, J.M. Finder, Y. Torri, and S.K. Dey

Nontraditional solution routes to ferroelectric materials
T.J. Boyle, H.N. Al-Shareef, C.D. Buchheit, R. Cygan, M.A. Rodriguez, B. Scott, and J.W. Ziller

Thick layer deposition of lead-based dielectric using diol-based chemical solution approach
D. Liu and J. Galvagni

The development of diol-based chemical solution deposition routes for single-coat fabrication of PZT thin films
R.W. Schwartz, T.L. Reichert, P. Clem, D. Dimos, and D. Liu

Orientation development in 60/40 PZT thin films from metallorganic precursors
J.L. Norton, G.L. Liedl, and E.B. Slamovich

Development of new ferroelectric source materials for MOCVD and MOD
Y. Okuhura, M. Matsumoto, H. Kadokura, and Y. Kojima

Chemical Vapor Deposition

ECR chemical vapor deposition of $(Ba,Sr)TiO_3$ thin films using liquid source injection
P. Alluri, D. Tang, and S.K. Dey

$SrBi_2Ta_2O_9$ ferroelectric films prepared by photo-assisted

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metallorganic chemical vapor deposition
A. Ignatiev, Q. Zhong, Y.M. Chen, and X. Zhang

MOCVD of ferroelectric and advanced dielectric thin films by liquid delivery
J.F. Roeder, S.M. Bilodeau, R.C. Carl, G.T. Stauf, I-S. Chen, and P.C. van Buskirk

In-situ low-temperature MOCVD growth of polycrystalline PZT/RuO_2/SiO_2/Si heterostructures
C.M. Foster, G-R. Bai, C. Bjorlander, and A. Wang

Multiwafer MOCVD systems for ferroelectrics
M. Deschler, E. Woelk, D. Schmitz, G. Strauch, and H. Jurgensen

Performance of $SrBi_2Ta_2O_9$ thin films grown by chemical vapor deposition for nonvolatile memory applications
C. Isobe, M. Sugiyama, K. Hironaka, K. Watanabe, M. Tanaka, H. Yamoto, H. Yagi, and T. Ami

The nonsolvent-based chemical vapor deposition route to $SrTiO_3$ and $(Ba,Sr)TiO_3$ materials for dynamic random access memory applications
K. Vydianathan, A.E. Kaloyeros, J.J. Sullivan, B. Han, L. Sullivan, and J. Loan

Microstructure and properties of $PbZr_{1-x}Ti_xO_3$ thin films made by one- and two-step metallorganic chemical vapor deposition
T. Li, P. Zawadzki, and R.A. Stall

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Increasing work is being done on integrating ferroelectric thin films with Si MEMS devices to expand the range of applications for microelectro-mechanical systems. The invited talk by Paul Muralt (EPFL) discussed numerous examples of integrated piezoelectric devices which utilized PZT films. The exciting use of piezoelectric (PZT) MEMS devices for biomolecular separation applications was introduced in the invited talk by Ronald McGlennen (University of Minnesota Medical School). Talks by D. Jenkins (University of Manchester) and T. Hidaka (HP Japan) also discussed the development of microactuated cantilevers and high-density recording media, respectively.

The session on testing and characterization covered a wide range of topics. The initial invited talk by Sam Al-Shareef (Sandia National Labs/Micron) demonstrated that fatigue can be viewed as a competition between domain wall pinning and unpinning, and the nominally fatigue-free systems are ones in which unpinning processes keep pace with pinning. He also showed that donor doping can be used to significantly improve the lifetime of PZT films against resistance degradation. The invited talk by Enrico Colla (EPFL) further elucidated the fatigued state of Pt/PZT/Pt capacitors as having an asymmetric polarization, based on piezoelectric measurements, which suggested preferential near-surface domain pinning. The invited talk by Domokos Hadnagy discussed the characterization of PZT memories in a production environment and showed how statistical testing can be used to assess reliability. Results from Northwestern University were presented in which TEM studies were used to characterize space charge fields by electron holography (Murray) and in-situ domain switching (Lin). In-situ switching studies were also carried out using atomic force microscopy, based on the piezoelectric effect (Auciello, Argonne National Lab). The resolution of AFM permitted identification of individual domain switching events. An elegant X-ray interference technique was also presented for assessing the domain orientation in epitaxial films (Foster, Argonne National Lab).

Individual sessions also focused on the three principal classes of fabrication techniques used for depositing ferroelectric thin films: chemical vapor deposition (CVD), chemical solution deposition (CSD), and physical vapor deposition (PVD). For applications with demanding requirements for conformal coverage, such as high-density memories, CVD is the most appropriate technique. Significant progress in CVD of perovskites was highlighted by the invited talks of Jeff Roeder (ATMI) for BST and PZT and C. Isobe (Sony) for SBT films. Commercial suppliers of CVD equipment such as Varian/ATMI, Aixtron GmbH (Deschler), and Emcore (Li) are also becoming more actively involved in the ferroelectric thin-film business. Liquid source misted chemical deposition offers an alternative fabrication approach (Solayappan, Symetrix).

CSD continues to offer a convenient and economical approach to fabricating ferroelectric thin films. This aspect is particularly important for high-volume, low-cost applications such as passive components (e.g., decoupling

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capacitors), as emphasized by David Liu (AVX Corporation). Both he and Bob Schwartz (Sandia National Labs) also emphasized that CSD approaches are ideal for building up relatively thick layers (~1μm), which are typically required for such applications. In addition, CSD approaches were shown to offer easy methods for film patterning using either direct electron-beam induced decomposition, as discussed in the invited talk by S. Okamura (Science Institute Tokyo), or photo-sensitive solutions, as presented by Uchida (Mitsubishi). The invited talk by Tim Boyle (Sandia National Labs) showed that the use of novel solution systems, such as pyridine based sols, and designer precursors could offer advantages for film synthesis. Control of solution chemistry was also emphasized in the invited talk by Y. Kojima (Kojunda Chemical) as the key to preparing improved precursors for MOCVD.

The session on PVD had papers dealing with growth and in-situ integration of materials by either Pulsed Laser Deposition (PLD) or sputtering. The invited talk by S. Aggarwal (University of Maryland) demonstrated successful in-situ integration of a TiN barrier layer with a PZT ferroelectric by PLD. In-situ monitoring and improved process control during ion beam sputtering was the focus of the invited talk by Alan Krauss (Argonne National Lab), who presented an in-situ ion beam technique for characterizing oxygen content in films. RF sputtering was also used for preparation of Bi-based layered perovskites (J.-K. Lee, KIST), BST (Suu, ULVAC), and $BaTiO_3$ (Su, Rice University).

The session on device integration addressed numerous cross-cutting issues for developing integrated devices. The focus of the invited talk by Joe Evans (Radiant Technologies) was on interlayer dielectrics and methods for minimizing any detrimental effects on PZT capacitors. Good work by S. Madhukar (University of Maryland), Jeon (LG Semicon), Kuah (University of Texas), and Nagata (Sharp) was presented on improved electrode stacks, which are critical for optimizing properties and permitting high-density integration. Development of good dry etching processes for both the ferroelectric and electrode layers remains a difficult issue (Cofer, Tegal), particularly for materials like Pt (Milkove, IBM). Degradation of ferroelectric and dielectric properties after forming gas anneals is also a critical problem. Han (Yale University) suggested that the severity of the forming gas anneal was related to the catalytic activity of the electrode material for decomposing H_2. Finally, the invited talk by Lorraine Francis (University of Minnesota) described the development of integrated acoustic sensors and a methodology for a solution approach that worked well in a multi-user (university) facility.

The 10th ISIF meeting will be held 1-4 March 1998 in Monterey, California. The technical chairs for the meeting will be Orlando Auciello and Chris M. Foster from Argonne National Laboratory. The first call for papers will be in August with abstracts due on 1 October 1997.

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Second-generation liquid source misted chemical deposition (LSMCD) technology for ferroelectric thin films
N. Solayappan, L.D. McMillan, and C.A. Paz de Araujo

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256BIT CMOS nonvolatile memory using low fatigue/imprint PZT capacitors
J.T. Evans, Jr., L. Boyer, B. Suizu, W.L. Warren, B.A. Tuttle, G.E. Pike, D. Dimos, R. Nasby, R. Ramesh, R. Womack, S. Desu, G. Menk, S. Collins, and S. Bernacki

New electrically conducting diffusion barriers for direct integration of ferroelectric capacitors on Si-CMOS
S. Madhukar, S. Aggarwal, B. Yang, A.M. Dhote, and R. Ramesh

Thermal stability of metal electrodes (Pt, Ru, & Ir) on polycrystalline silicon in ferroelectric capacitors
Y-C. Jeon, J-M. Seon, J-H. Joo, K-Y. Oh, J-S. Roh, J-J. Kim, C.Y. Kim, and Y-T. Choi

Interaction of Ir and IrO_2 thin films with polysilicon, W, and WSi_2
S.H. Kuah, V. Balu, T-S. Chen, B. Jiang, D. Hadad, B. White, R.E. Jones, P. Zurcher, S. Gillespie, and J.C. Lee

Pt-Rh based electrode with a novel stacked structure for ferroelectric memories
M. Nagata, S. Mitarai, Y. Ito, S. Onishi, J. Kudo, K. Sakiyama, S.B. Desu, H.D. Bhatt, D.P. Vijay, and Y. Hwang

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The effects of forming gas anneal on the electrical characteristics of Ir-electroded BST thin film capacitors
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Challenges for plasma etch integration of ferroelectric capacitors in FeRAMs and DRAMs
A. Cofer, P. Rajora, and S. DeOrnellas

Analysis of a fence-free platinum etch process
K.R. Milkove and C.X. Wang

Integrated acoustic sensors
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Top-electrode dependence of forming gas annealing effects on ferroelectric thin films
J-P. Han and T.P. Ma

New top and bottom electrodes for $SrBi_2Ta_2O_9$ ferroelectric capacitors
K. Katori, N. Nagel, K. Watanabe, M. Tanaka, H. Yamota, and H. Yagi

Influence of Ti content in the bottom electrodes on the ferroelectric properties of $SrBi_2Ta_2O_9$
W. Hartner, V. Joshi, G. Schindler, N. Solayappan, G. Derbenwick, and C. Mazure

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High-frequency dielectric properties of PLZT thin films
W. Williamson III, B.K. Gilbert, H.D. Chen, and L.E. Cross

Ferroelectric thin films for integrated passive components
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ife and reliability of BST capacitor integrated on GaAs MMIC
D. Ueda, T. Tanaka, and A. Noma

Materials specification for MCM-D decoupling capacitors using PZ, PZT, PLZT, and BST dielectrics
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M.V. Raymond, H.N. Al-Shareef, R.W. Schwartz, D.B. Dimos, N.A. Missert, and C. Mueller

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Performance of coplanar barium strontium titanium oxide thin film phase shifters fabricated by reactive ion etching
S. Stowell, W. Wilber, S. Sengupta, T. Koscica, L.C. Sengupta, and S.B. Desu

Pulsed laser deposition of ferroelectric thin films for room temperature active microwave electronics
A.C. Carter, J.S. Horowitz, D.B. Chrisey, J.M. Pond, S.W. Kirchoefer, and W. Chang

Growth and characterization of $SrTiO_3$ thin films for microwave tuning applications
C.H. Mueller, D. Galt, R.E. Treece, T.V. Rivkin, J.D. Webb, and H.R. Moutinho

On the voltage linearity and scalability of thin film high capacitance density devices using $[X(Ba_{n1}Sr_{n2}(Nb, Ta)_{10}O_{30+(1-x)}SrTiO_3]$ solid solutions
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Extra space charge in capacitor structures based on $SrTiO_3$ and $Ba_{0.5}Sr_{0.5}TiO_3$
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Microwave properties of $YBa_2Cu_3O_{7-x}/SrTiO_3$ planar capacitors
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Preparation and characterization of sol-gel derived Sn-doped $ZrTiO_4$ thin films
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Pyroelectric properties of various sol-gel derived PZT thin films
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Platinum thin film bolometer for surface temperature measurement of a pyroelectric detector
S.B. Xiong, Y.M. Liu, and Z.G. Liu

DRAMs and Materials

Effect of Mn doping on the DRAM-relevant properties of CSD processed $(Ba_{1-x}Sr_x)TiO_3$ thin films
S. Hoffmann, M. Schumacher, and R. Waser

Thin film deposition of barium strontium titanate (BST) by metallorganic deposition (MOD) technique
P. Jana and R.K. Pandey

Sol-gel barium strontium titanate films for DRAMs and MMICs
A.S. Sigov, V.A. Vasiljev, K.A. Vorotilov, L.I. Solovjeva, and M.I. Yanovskaya

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Piezoelectric and pyroelectric properties of sol-gel derived ZnO thin films
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Piezoelectric properties of PZT and AIN thin films for microactuators and acoustic sensors
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Influence of the processing parameters on the piezoelectric properties of sputtered lead-based ferroelectric thin films
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The effect of finite electrical resistance on the polarization measurement of ferroelectric capacitors
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Polarizability-induced isotope effect in displacive and order-disorder type ferroelectrics
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Asymmetric switching and imprint in $(La,Sr)CoO_3/Pb(Zr,Ti)O_3/(La,Sr)CoO_3$ heterostructures
C.H. Choi and J. Lee

Imprint characterization of ferroelectric capacitors using quasi-linear fourier analysis
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Direct observation of potential distribution across ferroelectric capacitor using off-axis electron holography
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E.N. Paton, S.A. Mansour, and A. Bement, Jr.

Partial clamping effect on ferroelectric integrated films' electrical properties
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Low imprint characteristics of $SrBi_2Ta_2O_9$ and $SrBi_2(Ta_{1-x}Nb_x)O_9$
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Fatigue behaviors of all sol-gel derived RuO_2-PZT-RuO_2 ferroelectric capacitors
G. Teowee, J.M. Boulton, S.M. Hassan, K.C. McCarthy, F.S. McCarthy, T.J. Bukowski, T.P. Alexander, and D.R. Uhlmann

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Structural and electrical properties of $Ba_{0.5}Sr_{0.5}TiO_3$ thin films grown by liquid source chemical vapor deposition
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Fabrication and characterization of BST thin films by liquid source chemical vapor deposition
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Characterization of RuO_2 thin films prepared by hot-wall metallorganic chemical vapor deposition
W-C. Shin and S-G. Yoon

Autostoichiometric vapor deposition of ferroelectrics--The stoichiometry of co-evaporations
R.C. Zhang and R. Xu

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Improvement of electric properties on doped PZT and SBT using a sol-gel method
H. Ashida, T. Tamura, and S. Ohtani

A novel method for preparing PZT and other metal-oxide thin films from solution
B-M. Gong, R.H. Estes, and F.W. Kulesza

A novel propionate-based chemical solution deposition method of $La_{1-x}(Ca,Sr)_xMnO_3$ thin films for microelectronic applications
U. Hasenkox, C. Mitze, and R. Waser

Chemistry of the alkoxy-derived precursor solutions for layer-structured perovskite thin films
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Sol-gel processing of $BaSrTiO_3$ films
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Processing effects on stoichiometry of hydrothermally derived $Ba_xSr_{1-x}TiO_3$ powders and films
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Preparation of self-patterned BST thin films from photosensitive solutions
N. Soyama, H. Uchida, K. Ogi, and C.A. Paz de Araujo

Sol-gel derived ferroelectric-ferromagnetic $BiFeO_3$-$PbTiO_3$ films
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Electrical properties of $SrBi_2Ta_2O_9$ thin films deposited by RF magnetron sputtering
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PLANNING WORKSHOP

PIEZOELECTRIC CRYSTALS FOR ELECTROMECHANICAL TRANSDUCTION

The Materials Division of the Office of Naval Research announces a program interest in the area of piezoelectric crystals for electromechanical transduction.

This integrated science and technology thrust on transduction materials targets exploitation of a recently announced **research breakthrough with single crystals of relaxor ferroelectrics.** Specifically, these crystals exhibit piezoelectric strains exceeding one percent -- more than ten times that of conventional polycrystalline piezoelectrics. Their high strain levels and their high electromechanical coupling (exceeding 90 percent) point to a revolution in acoustic transduction made possible by these relaxor piezocrystals. A broad range of applications for these transducer materials are readily envisioned. In the specifically naval arena, uses range from all forms of sonar -- surveillance, tacticial, navigation, undersea weapons and diver-held -- to acoustic signature control (active mounts and acoustic coatings), while other defense/civilian uses encompass aircraft control (rotorblade and airfoil shape), auditory noise suppression, medical ultrasonics (diagnostic and therapeutic), machine tool control, and the like. While this program concentrates on transducer materials and device issues, the program will be defined in conjunction with system application specialists, in order to insure rapid system application of materials/device science/technology innovations.

To provide an opportunity for the science and technology community to advise on how to exploit this research breakthrough, a **Planning Workshop** on Piezoelectric Crystals will be held 14-16 May 1997 in the Washington, D.C., area. Details on participating in this open public workshop can be obtained from the Workshop Coordinator: Ms. Vickie Michelson, Management Resources Incorporated, 1815 North Fort Myer Drive, Suite 509, Arlington, VA 22209, phone: (703) 243-1655, fax: (703) 312-8620, and e-mail: mrinc@erols.com. This workshop, along with system application studies now getting underway, will contribute to formulating the precise size and scope of this program thrust.

At present, we anticipate that the program will focus on innovative materials and device research that aims at

(1) devising cost-effective methods to synthesize the materials in the forms (bulk, film, fiber, multilayer, etc.) required in applications
(2) understanding the basic origins of the macroscopic properties in order to optimize the materials performance, and
(3) inserting these materials into practical system applications.

Potential performers should summarize their proposed constributions in a three- to five-page concept paper that describes the transduction materials science research and technology development proposed, as well as its expected impact in the applications arena. Along with a rough order of magnitude of the proposed program's costs, these concept papers should be submitted to: Dr. Wallace Arden Smith, Office of Naval Research, Materials Division, ONR 332, 800 North Quincy Street, Room 502, Arlington, VA 22217-5660, phone: (703) 696-0284, fax: (703) 696-0934, e-mail: smithw@onr.navy.mil. Responses to these initial inquiries will be made on a continuous basis, and projects will similarly begin continuously as meritorious research and development efforts are delineated.

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For mail/e-mail addresses and phone/fax numbers, please see page 1

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Co-fired piezoelectric multilayer transformers
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PLZT ceramics electrooptic modulators for infrared solid state Nd:YAG and Er:YAG lasers
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Liquid crystalline structures: From molecules to devices
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Electromechanical control: Novel applications, relaxors, materials, MLAs, and drives

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S. Watanabe, T. Fujiu, and T. Fujii

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CALENDAR OF EVENTS 1997

May 14-16	*	Planning Workshop on Piezoelectric Crystals, Washington DC area (see p. 9)
28-31	•	FMA-14, Coop-Inn Kyoto, Kyoto, Japan
Jun 1-4	•	15th Conferenc on Crystal Growth and Epitaxy, Stanford Sierra Camp, Fallen Leaf Lake, California (see *Ferroelectricity Newsletter*, Vol. 4, No. 4, p. 22)
25-27	•	7th International Seminar on Ferroelastic Physics (ISFP-7), Kazan, Russia (see *Ferroelectricity Newsletter*, Vol. 5, No. 1, p. 17)
Jul 6-11	•	Gordon Research Conference on Crystal Growth and Epitaxial Thin Films. Information: phone +(401) 783-4011/3372, fax +(401) 783-7644, e-mail app@gremail.grc.uri.edu
Aug 24-29	•	9th International Meeting on Ferroelectricity (IMF-9), Seoul, Korea (see *Ferroelectricity Newsletter*, Vol. 4, No. 3, p. 10)
Sep 29-**Oct** 1	•	2nd European Meeting on Integrated Ferroelectrics (EMIF-2), Jouy-en-Josas, France (see *Ferroelectricity Newsletter*, Vol. 5, No. 1, p. 19)

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Mar 1-4	•	10th International Symposium on Integrated Ferroelectrics (ISIF 98), Monterey, California
Apr 6-10	•	5th International Symposium on Ferroic Domains and Mesoscopic Structures (ISFD-5), University Park, Pennsylvania
Aug 24-27	•	11th International Symposium on Applications of Ferroelectrics (ISAF XI), European Conference on Applications of Polar Dielectrics (ECAPD IV), and Electroceramics VI, Montreux, Switzerland
Dec 8-11	•	2nd Asian Meeting on Ferroelectrics, Singapore

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